DIVISION OF RESEARCH, INNOVATION & SYSTEM INFORMATION (DRISI)
Research Initial Scope of Work
SUBMITTAL FORM - FY 13/14

I. **Project Number:** P860
Project Title: Automated Video Incident Detection System (AVID)

II. **Task Number:** 2531
Task Title: Automated Video Incident Detection System (AVID)

III. **Project Problem Statement:**

Verification of incidents on major freeways is one of the most critical functions for incident response. Studies show that every seven minute delay in verification results in one additional mile of queue in the system. Therefore, early verification of an incident results in less congestion and rapid restoration of the traffic. One of the methods that Transportation Management Centers (TMC) use to verify an incident is the use of existing CCTV cameras once the incident is identified. The cameras are normally in idle mode and are not performing any functions prior to utilizing them for incident verification. In general, the CCTV cameras are in the idle mode over 95% of the time. The Department lacks an automated methodology to verify incidents and the existing CCTV cameras are utilized passively for incident verification after the TMC is informed of an incident.

IV. **Objective:**

The objective of this project is to build the ability to utilize the existing CCTV cameras to automatically detect and report freeway incidents in a more intelligent fashion, and provide the information to TMC operators and managers in real time for a much quicker verification and response. Moreover, this project will deploy intelligence on the existing freeway cameras for the purpose of detecting and reporting the following incident types utilizing a variety of analytical events, such as:

- Disabled or stopped vehicles on the highway.
- Presence of debris or objects on the roadway.
- Real-time traffic congestion levels.
- Vehicle classification investigation.

The system also will have automated alarms for:

- Traffic Congestion- the ability to identify congestion on roads based on the volume of cars and their movement.
- Stationary Vehicle – the ability to identify a stationary vehicle for a user defined time in a defined zone.
- Unattended Object – the detection of objects of a given size within a defined zone.
- Video Source interruption – the alert notification of a video signal disruption caused by lost signal from a camera, sabotage of camera displacement, too dark or too bright.

V. Task Description of Work and Expected Deliverables:

In partnership with Caltrans District 12 TMC and DRISI staff, the research team will define all the video analytic requirements to deliver a comprehensive pilot project that will demonstrate the capabilities of a selected Video Detection Application System (VDAS) tool (e.g. SmartCatch or Citilog), which automates the video surveillance of CCTV cameras and can provide huge benefits in increasing safety of traveling public while lowering operating costs. Benefits include increasing the accuracy and efficiency of human monitoring, insuring instantaneous detection of events that might otherwise go unobserved, and enabling security officials to rapidly respond at the first sign of a security threat. Partnering with outside vendors that possess an acceptable VDAS solution in encouraged for a successful delivery of this project.

The following preliminary tasks are envisioned to deliver the above mentioned requirement:

Task 1: Comprehensive literature search for any VDAS tools currently available on the open market.

Deliverable: Report outlining the available VDAS tools, with pros and cons of each one.

Task 2: In consultation with District 12 staff, select 6-10 existing freeway camera locations for the purpose of obtaining recorded videos, provided by Caltrans, and conducting an evaluation of a number of VDAS tools selected from Task 1 in a laboratory environment suitable for detecting the following incident types utilizing a variety of analytical behaviors:

- Disabled or stopped vehicles on the side of the highway
- Presence of a stationary object in the roadway indicating debris or a disabled vehicle in the roadway.
- Real-time traffic congestion levels.
- Vehicle classification investigation

The evaluation should be performed based on the following criteria:

Test I: Disabled Vehicles

Detect the presence of disabled vehicles on both sides of the road with the same camera view. The tests will be conducted on vehicles which appear as small as 20 x 20 pixels to those much larger. The detection period shall vary from a low of 2 minutes to as high as 15 minutes. Simulations shall be run at different times of day, including those times with shadows moving across the roadway.

Test II: Stationary vehicle or debris in roadway

We realize that this test may be more difficult to simulate. To the extent possible, simulate the presence of debris on the roadway (It may be better to run the tests with debris being placed on the side of the road.) Detect debris as small as 20x20 pixels with a minimum detection time of 1 minute.

Test III: Collect real-time congestion
Collect roadway statistics information on occupancy (level of congestion). All statistics data shall be written into a MySQL database. The data shall be displayed in real-time via Excel. If desired, Caltrans may set thresholds for congestion in which an alert will appear. Data shall be collected continuously.
Deliverable: A report outlining the results of the evaluations on selected VDAS tool for the 6-10 camera locations.

Task 3: Armed with the results of Task 2, conduct a limited field pilot study with real time video data as a proof of concept. The VDAS tool will receive analog video directly from Caltrans Video Switch Matrix or another distribution point approved by Caltrans team. In this task, the research team will also analyze the issues related to integration of the VDAS tool into TMC Advanced Transportation Management System (ATMS) software and propose solutions for full integration including enhancement to the user interface, alert protocols for notification of TMC operators, communication protocols between VDAS and ATMS, and capabilities of the VDAS client in TMC.

VDAS must meet the following detection requirement:

- For Traffic Congestion, a congestion percentage will be logged in the Video Detection Application database every 30 seconds; once that percentage exceeds a user defined number an event will be generated.
- For Stationary Vehicle, all vehicles that are motionless for a defined period in a defined location.
- For Unattended Object, any object greater than the minimum size that is not occluded for more than 10 seconds at any point of time during the detection period.

Accuracy assumptions:

- Camera must not shake or be prone to vibration greater than 3 pixels.
- Lighting conditions are such that day light or artificial light is continuously present. Lighting may vary, but some reasonable contrast needs to be maintained.
- The camera view/position cannot be moved once the software is configured.
- The behavior can only process information as what is visibly captured. Any occlusions cannot be processed.

Deliverable: A report discussing the proof of concept procedures and results, a checklist outlining the integration procedures with ATMS, issues related to full deployment and possible solutions. In addition all hardware, application software, integration protocols, and source codes documentation for detection of incidents shall be part of the deliverables.

VI. Background:

Presently, The TMC operators monitor and manage the freeway system for recurrent and non-recurrent congestion and incidents. The operators can verify an incident upon either receiving calls from commuters, monitor CHP log, news media or viewing the Advanced Transportation Management System (ATMS) map, which

presents the freeway speed through the vehicle detection system in a TMC. Once the operators are informed of an incident they utilize the CCTV cameras to verify the incident prior to taking appropriate action in responding and removing the incident. Therefore, there is a time loss between the period that the operators are informed and the incident are verified through the existing CCTV cameras. This time loss will add a few minutes to the verification time of an incident, resulting in additional total delay.

This project is proposing to build intelligence in the TMC central system to allow the CCTV cameras proactively detect abrupt changes in traffic conditions on the freeway in real time and alerting the TMC operators visually by depicting the traffic condition on the TMC monitors automatically. In this approach the operators can instantly detect and verify incidents in real time without undue delay. The automated CCTV camera system can provide a high rate of detection including the rapid congestion, stationary vehicles, and unattended objects.

VII. Estimate of Duration:

It is estimated that this project will take up to 24 months to complete at a cost not to exceed $250,000.

VIII. Related Research:

In a Preliminary Investigation Report sponsored by Caltrans Division of Research, Innovation, and System Information (DRISI) dated October 28, 2012 (which can be found at: http://www.dot.ca.gov/newtech/researchreports/preliminary_investigations/docs/automated_incident_pi.pdf), information was gathered in three areas: Installation and Efficacy, Incident Detection System and Algorithm Development, and Research in Progress. Summary of findings in each area is listed below:

- **Installation and Efficacy**
  Studies show mixed results about the accuracy of automated video incident detection systems.
  - The results of one study presented at a 2008 conference shows 85 percent accuracy for these systems.
  - A 2007 California study illustrates the significant number of false alarms generated by such systems, and a 2006 journal article reports on poor performance because of low maturity of the technology, complex algorithms due to the provision of extensive functionality, and suboptimal camera location and height for image processing.
  - A 2005 conference paper about a Caltrans study found an automatic incident detection system on the San-Mateo Bridge to be efficient in detecting accidents and incidents, and not significantly affected by adverse weather conditions. A 2005 report by the Virginia Transportation Research Council similarly found a system to be effective.
  - A 2004 study by the University of Utah Traffic Lab compares several vendors, finding Traficon to be the most accurate at 96 percent. Systems performed well under day and dusk conditions and during inclement weather conditions.

- **Incident Detection System and Algorithm Development**
  Several studies discuss the challenges of developing automated incident detection systems, including algorithms that minimize false alarms.
  - A 2012 TRB Annual Meeting paper shows that use of automated incident detection in nationwide traffic management centers is limited because of the high rates of false alarms and calibration complexity.
  - A 2008 conference paper similarly shows that these systems have not been widely deployed in England because of "false alert rates which have added unnecessarily to the workload of control room operators," and looks for solutions to overcome these problems.
  - A 2010 Institute of Electrical and Electronics Engineers (IEEE) conference paper shows that good performance can be obtained for video-based incident detection of wrong-way drivers, still standing vehicles and traffic jams.
  - A 2008 IEEE paper reviews the challenges of false alarms because of glare, snow, rain and shadows.
  - Other studies evaluate various algorithms for automated incident detection.

- **Research In Progress**
  - We found one project in progress at the University of Maryland that is evaluating the use of high definition video for traffic monitoring and analysis. This study includes "the development of real-time 'event' detection algorithms specially tailored to our unique combination of HD image capture, wireless transport, and real-time processing."

IX. Deployment Potential:

Upon completion of this project, Caltrans will evaluate the system performance of this application, which includes a delay savings report on the benefit of the AVID in comparison with the operators detecting and verifying the incidents manually. This will determine the development and deployment potential of this application in District 12 at first, and other districts at a later stage.

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Date: 6/20/13